Tooth Profile of a Spline Shaft

The present invention relates to a tooth profile according to the preamble of claim 1.

Parallel key or sliding feather key connections are often used for the positive connection of a hub with a shaft. If large torques are to be transmitted and a displacement is to be rendered possible between hub and shaft, a multiple-groove profile or a spline shaft is often used.

The grooves thereby often have either a rectangular or a trapezoidal profile. The profiles are thereby produced either by machining or by cold forming, such as, e.g., by impact roll methods. Compared to machining, cold forming has above all the advantage of greater cost-effectiveness with large quantities to be produced.

Particularly with cold forming, in the production of such profiles a number of parameters are of crucial importance for the precision of the profile. These are in particular the diameter, the tooth thickness, the pitch, the groove flank or tooth flank shape and direction, the ovality of the workpiece, etc. The fits of these individual parameters ultimately accumulate into fit errors between hub and shaft, which are significant for an effective connection between hub and shaft. These fits are therefore to be designed with sufficient play in order to make a connection possible at all. However, this necessary play now leads to a reduction in the quality of the mating between hub and shaft, which has a negative impact, depending on the parameters and application purpose of the connection. In the subsequent cold forming, the quality requirements for these workpieces can often be met only to a qualified extent due to the inhomogeneities of the raw material.

These problems can occur with clutch disk carriers for automatic transmissions for vehicles or, e.g., markedly in the production of drive-shaft telescopic tubes, which are used in large numbers, e.g., in vehicle construction. Respectively one inner tube and one outer tube with corresponding profiling on the inside or outside are used. Due to the large production runs, the cold working method is very important for an economic production, but very high demands are made on

the precision of the profile connection between inner and outer tube due to the high rotational speed of drive-shaft telescopic tubes during operation.

In the use of conventional profiles, a buckling play develops between the two tubes, caused by the usually large profile length, which in operation can lead to unacceptable radial movements of the drive shaft, which can go as far as the destruction of the drive shaft at high loads and rotational speeds. The buckling play is caused by the radial play between the profile of the inner and outer tube.

The object of the present invention was to find a tooth profile for drive components, in particular for drive shafts embodied in a displaceable manner with respect to one another, with which the radial play is minimized or even eliminated.

This object is attained according to the invention through a tooth profile with the features of claim 1. Further embodiments preferred according to the invention will be apparent from the features of further claims 2 through 6.

The groove profile according to the invention for a positive hub-shaft connection with an essentially rectangular or trapezoidal groove cross section has at least one rib projecting radially outwards on the groove root or on the groove head either of the hub or of the shaft. A linear-areal support is thus formed in the radial direction with respect to the longitudinal axis of the hub or of the shaft. Such a support can be embodied advantageously with little play or completely free from play.

Preferably each groove root or each groove head of the hub or of the shaft has at least one rib. A defined connection of the profiles between hub and shaft is thus obtained along the entire circumference and an exact radial positioning of the shaft in the hub is achieved.

The rib is preferably embodied running parallel to the flank of the groove, preferably along the entire length of the corresponding groove root or groove head. Particularly with large tooth lengths, such as occur in telescopic tubes, a

precise radial linear-areal connection is thus achieved between the grooves of the hub and the shaft, or of the inner and outer tube.

The rib preferably has a trapezoidal cross section tapering outwards. This type of shape is easy to produce by cold forming and has a high dimensional stability. The rib preferably has a maximum width of 50%, preferably 25%, of the width of the corresponding groove root or groove head. The narrower the rib is embodied, the smaller the support surface of the rib head becomes on the corresponding surface of the opposite groove root or groove head. Precise geometric conditions can thus also be achieved over larger profile lengths.

The radius of the support surface of the rib to the opposite groove root or head is preferably embodied free from play or with initial stress with respect to the longitudinal axis of the hub or the shaft. The radial play between the hub and the shaft can thus be virtually completely neutralized. Furthermore, it has been shown that even an initial stress can be built up, i.e., the radius of the support surface of the rib is larger than the radius of the groove root or groove head opposite if the ribs are embodied on the hub profile. This is suitable in particular with thin-walled hollow profiles, whereby either the hub or the shaft or both parts are embodied as hollow profiles. Furthermore, ovality of the cross section, also caused by inhomogeneities of the material and occurring particularly with hollow profiles, can thus advantageously be corrected.

At least two ribs arranged parallel to one another are preferably respectively embodied in one groove root or groove head. It can be advantageous to provide more than one rib according to the dimensions of the profiles and the dimensions of hub and shaft and the forces and rotational speeds to be transmitted.

The pockets formed next to the rib or ribs and between the surfaces of the profile roots or profile heads lying radially opposite have furthermore proven very advantageous for the distribution of lubricant in the interspace of the profiles.

The object is further attained through a telescopic tube for drive shafts with an inner tube and an outer tube, in which the inner tube or the outer tube has a groove profile according to one of claims 1 through 6.

The inner tube and the outer tube are thereby preferably embodied as hollow bodies with approximately uniform profile thickness. Drive shafts of this type are particularly suitable for use in motor vehicles for power transmission from the engine to the drive axles or drive wheels.

Furthermore according to the invention a method is proposed for producing a groove profile according to one of claims 1 through 6 by the cold-rolling method, in which one or more profile rolls or profile rollers are brought into engagement with the surface of the hub or shaft in conformity with the profile mandrel necessary for profiling and located within the hollow member and having a profile embodied in accordance with the rib. The rib can thus be advantageously produced in one operation together with the embodiment of the grooves.

The profile rolls or profile rollers are preferably brought into periodic impacting engagement. Particularly precise profiles can be produced through this impact roll process.

An exemplary embodiment of the present invention is explained in more detail below on the basis of drawings. They show:

Fig. 1 The cross section through a telescopic tube with groove profile according to the invention;

Fig. 2 The cross section through a section of a groove from Fig. 1 embodied according to the invention;

Fig. 3 The cross section of a section of an alternative embodiment variant of a telescopic tube;

Fig. 4 The cross section of a section of another alternative embodiment variant of a telescopic tube;

Fig. 5 The cross section through a section according to Fig. 2 with an alternative embodiment of the groove according to the invention.

Fig. 1 shows the cross section through the outer tube 1 and inner tube 2 of a telescopic tube, such as is used, e.g., in vehicle construction, which inner tube and outer tube are embodied as a hollow profile. Both the outer tube 1 and the

inner tube 2 thereby have a profiling arranged uniformly along the circumference and having a groove 3 with a trapezoidal cross section.

Fig. 2 shows in more detail the section of a single groove profile of the telescopic tube according to Fig. 1. The outer tube 1 thereby has a groove 3 embodied inwardly and trapezoidal in shape with a groove head 4 directed towards the inside. The groove head 4 has a cylindrical surface with respect to the longitudinal axis of the telescopic tube. The inner tube has a groove 3 embodied accordingly with a groove root 5 directed towards the outside. The groove root 5 likewise has a cylindrical surface analogous to the groove head 4.

A rib 6 projecting radially outwards is now embodied in the groove root 5. In this example the front face 6' of the rib 6 rests in the center of the groove head 4 of the outer tube advantageously without play. Practically a point-to-surface or, with regard to the longitudinal extension of the grooves 3, a line-to-surface connection is created through the small support width b compared to the groove width B of the groove head 4. Furthermore, the small width b of the rib 6 permits a precise production while maintaining the lowest tolerances even with cold forming, which allows the mating to be designed free from play in the first place.

The flanks 7 facing one another of the grooves 3 of the outer tube 1 and the inner tube 2 respectively advantageously have a little play with respect to one another in order to compensate for inaccuracies of the flank angle and the pitch of the grooves during the production of the groove profile and to render possible a mating of outer tube 1 and inner tube 2. The play can be, e.g., approx. 0.05 mm with an average tube diameter of 100 mm and a wall thickness of 2 mm. Such values can be achieved with cold forming methods.

If each groove root 5 of each groove 3 of the inner tube 2 now advantageously has a rib 6 of this type, the radial play of the connection between outer tube 1 and inner tube 2 can thus be advantageously completely neutralized. The buckling play harmful with such telescopic tubes is thus also reliably neutralized.

Figs. 3 and 4 show further exemplary embodiments of the groove profile according to the invention with rib 6 on thick-walled tube profiles 1' or 2'. It is

clear that a combination of two thick-walled tube profiles 1' and 2' is also conceivable, as a solid profile can also be used as inner tube 2.

Fig. 5 shows still a further alternative embodiment of the groove profile according to the invention, whereby two ribs 6 lying parallel to one another are here embodied in the groove root 5. Incidentally, it has been shown that the pockets 8 embodied between the ribs 6 and the groove root 5 or groove head 4 are optimally suitable for the accommodation and distribution of lubricants and have better lubricant properties compared to conventional groove profiles without ribs 6.

It is self-evident to one skilled in the art that the ribs 6 can also be embodied, e.g., on the inside of the outer tube 1 on the groove head 4 and consequently point inwards. The ribs 6 can also be respectively arranged on the groove head of the inner tube 2 or the groove root of the outer tube 1.

Since the ribs 6 can be produced in exact dimensions, instead of neutralizing the play between the front faces 6' of the rib 6 and the groove head 4 lying opposite, an initial stress can be set in that the front face 6' has a larger radius with respect to the longitudinal axis of the outer tube 1 or of the inner tube 2 than the radius of the groove head 4. This is very particularly suitable for use with thin-walled outer (1) or inner (2) tubes, whereby possible ovalities, i.e., deviations from the exact circular form, can thus also be offset there.